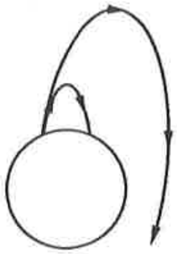
62.



Best explanation due to Newton. Consider a projectile being thrown faster and faster from the spherical earth. It still falls to meet the earth, but the earth curves away from it. The two suns fall together but never touch.

(b) $m(2\pi/T)^2 r = Gm^2/(2r)^2$.
$m = 4(4 \times 10^{10})^3(2\pi/3.98 \times 10^8\ s)^2/(6.67 \times 10^{-11}\ N\ .\ m^2/kg^2) = \underline{9.57 \times 10^{26}\ kg}$.

Chapter 6

1. $W = Fd = mgh = (55)(9.8)(5) = \underline{2.7 \times 10^3 \text{ J}}$

2. (a) $(150)(3) = \underline{450 \text{ J}}$.

   (b) $(650)(3) = \underline{1950 \text{ J}}$

3. $W = Fd = \mu mgd = (0.06)(200)(9.8)(50\ 000) = \underline{5.9 \times 10^6 \text{ J}}$

4. $F = W/d = 6 \times 10^4/2000 = \underline{30 \text{ N}}$

5. Work stored is $mgh = (200 \text{ kg})(9.8 \text{ m/s}^2)h = 13000$ J. $h = \underline{6.63 \text{ m}}$.

6. Vertical distance = (245 m) sin (22.5°) = 93.8 m

   (a) $(1000 \text{ kg})(9.8 \text{ m/s}^2)(93.8 \text{ m}) = \underline{9.19 \times 10^5 \text{ J}}$

   (b) Friction force = $(0.30)(1000 \text{ kg})(9.80 \text{ m/s}^2) \cos(22.5^\circ) = 2716$ N
   Friction work = $(2716 \text{ N})(245 \text{ m}) = 6.65 \times 10^5$ J
   Total work = $9.19 \times 10^5 \text{ J} + 6.65 \times 10^6 \text{ J} = \underline{1.58 \times 10^6 \text{ J}}$

7. (80 N)(0.36 m) = 29 J

8. 1st brick: work = 0 J
   2nd brick: work = $(1.2 \text{ kg})(9.8 \text{ m/s}^2)(0.060 \text{ m}) = 0.7056$ J
   3rd brick: work = $2 \times (0.7056 \text{ J})$
   4th brick: work = $3 \times (0.7056 \text{ J})$
   .
   .
   .
   8th brick: work = $7 \times (0.7056 \text{ J})$ =
   Total work = $(0.7056 \text{ J})(1 + 2 + 3 + 4 + 5 + 6 + 7) = 19.8 \text{ J} = 20$ J

9. (a) Gravity force = (300 kg)(9.80 m/s²) sin (25°) = 1242 N
Friction force = (0.40)(300 kg)(9.80 m/s²) cos (25°) = 1066 N
Force by man = 1242 N − 1066 N = 180 N

(b) Work by man = (176 N)(4.5 m) cos (180°) = −800 J

(c) Work by friction = (1066 N)(4.5 m) cos (180°) = −4800 J

(d) Work by gravity = (1242 N)(4.5 m) cos (0°) = 5600 J

(e) Net work = 5589 J − 793 J − 4797 J = 0J with round-off.

10. (a) $F - Mg = m(0.10\ g)$
$F = M(1.10g) = 1.10\ Mg$

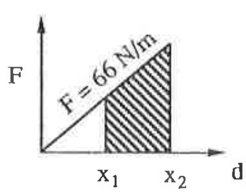
(b) $W = F \cdot d = (1.10\ Mg)(h) = 1.10\ Mgh$

11. Estimate $F_a \cos \theta = 150$ N, $F_b \cos \theta = 250$ N
Assume curve from (6.0 m, 150 N) to (30.0 m, 250 N) is a straight line.
Work = (30.0 m − 6.0 m)(150 N + 250 N)/2 = 4900 J

12. (a) Work done = area under curve.
For, $x = 0$ to 10, area is given by $A = 7 \times 400 = 2800$ J.

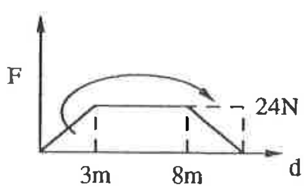
(b) For $x = 10$ to 15 W is negative
$W = -(200 \times 2 + 1.5 \times 200) = -700$ J.
Net work from $x = 0 - 15 = (2800 - 700)$J = 2100 J.

13.

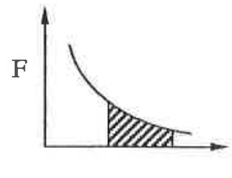


Area under curve = $1/2(F_1 + F_2)(x_2 - x_1) = 1/2\ k(x_2^2 - x_1^2) = 0.0701$ J.

14.



Area under curve easily obtained by moving triangle
= (24 N)(11 m − 3 m) = 192 J.

15. 

$F = GMem/r^2$. Area $\simeq$ 1.5 × 10^{10} J.

16. $\frac{1}{2}mv^2 = (0.5 \times 10^{-6}\ \text{kg})(0.30\ \text{m/s})^2/2 = 2.25 \times 10^{-8}\ \text{J}$.

17. $v^2 = (2KE/m) = 2(4.64 \times 10^{-19}\ \text{J})/(1.99 \times 10^{-26}\ \text{kg})$. $v = 6.83 \times 10^3\ \text{m/s}$.

18. KE doubled, v^2 doubled, v increased by a factor of $\sqrt{2}$.

19. v doubled, KE increased by a factor of $2^2 = 4$.

20. $W = \Delta KE = mv^2/2 = (9.11 \times 10^{-31})(5 \times 10^6)^2/2 = 1.14 \times 10^{-17}\ \text{J}$

21. $W = mv^2/2 = (1000\ \text{kg})(27.8\ \text{m/s})^2/2 = 3.86 \times 10^5\ \text{J}$.

22. KE lost by = PE gained by spring
40 km/hr ≡ 11.1 m/s

$\frac{1}{2}(1350\ \text{kg})(11.1\ \text{m/s})^2 = \frac{1}{2}K(2.5\ \text{m})^2$

$K = 2.66 \times 10^4\ \text{N/m}$

23. Work = $\frac{1}{2}(0.140\ \text{kg})(30\ \text{m/s})^2 = 63\ \text{J}$

Force = (63 J)/(0.15 m) = 420 N

24. Work to stop car = $\frac{1}{2}m(1.5v)^2 = (2.25)\left[\frac{1}{2}mv^2\right]$

Work = Braking Force × distance
Braking Force is same, so distance is 2.25 times original

25. (a) work = (80 kg)(50 m/s)^2/2 = <u>1.0 × 10^5 J</u>

(b) Force = (1.0 × 10^5 J)/(1.1 m) = <u>9.10 × 10^4 N</u>

(c) Work done by gravity (W_g) = mgh (assuming that plane was at rest when he jumped) is (80 kg)(9.8 m/s^2)(370 m) = 2.9 × 10^5 J

$$W_{tot} = W_g + W_{air} = \frac{1}{2}mv^2$$

W_{air} = 10^5 J − 2.9 × 10^5 J
= <u>−1.9 × 10^5 J</u>

W_{air} <u>must</u> be negative. It was slowing him down–not accelerating him.

26. $\frac{1}{2}(2\ m_2)v_1^2 = \left(\frac{1}{2}\right)\frac{1}{2}m_2v_2^2$

$\frac{1}{2}(2m_2)(v_1 + 5)^2 = \frac{1}{2}m_2(v_2 + 5)^2$

Solving, v_1 = <u>3.54 m/s</u>

v_2 = <u>7.07 m/s</u>

27. (a) T − (180 kg)(9.80 m/s^2) = (180 kg)(0.15)(9.80 m/s^2)
T = <u>2030 N</u>

(b) Net work = (180 kg)(0.15)(9.80 m/s^2)(23.0 m) = <u>6090 J</u> = 6.09 × 10^3 J

(c) Work by cable = (2029 N)(23.0 m) = <u>46 667 J</u> = 4.67 × 10^4 J

(d) Work by gravity = −(180 kg)(9.80 m/s^2)(23.0 m) = <u>−40 600 J</u> = −4.06 × 10^4 J

(e) 6086 J = $\frac{1}{2}$(180 kg)v^2 − $\frac{1}{2}$(180 kg)(0 m/s)^2

v = <u>8.22 m/s</u>

28. $P.E. = \frac{1}{2}kx^2 \Rightarrow 60\ J = \frac{1}{2}(380\ N/m)x^2$

x = <u>0.56 m</u>.

29. Gain in $PE = mg\Delta h$ = (4.3 kg)(9.8 m/s^2)(1.3 m)
ΔPE = <u>55 J</u>.

30. (a) mgh = (0.280 kg)(9.8 m/s^2)(2.45 m) = 6.72 J.

(b) mgh = (0.280 kg)(9.8 m/s^2)(2.45 m − 1.8 m) = 1.78 J.

(c) 6.72 J is work done by person on the book. 1.78 J is partial work done in section from head to top.

31. (a) mgh = (65 kg)(9.8 m/s^2)(2800 m − 1600 m) = 7.6×10^5 J.

(b) 7.6×10^5 J.

(c) Yes. Produces heat as well – thermal energy.

32. (a) $kx^2/2 - kx_0^2/2$.

(b) $kx^2/2 - kx_0^2/2 = 0$

33. $mv^2/2 = mgh$. h = 0.5(6 m/s)^2/(9.8 m/s^2) = 1.8 m. No. Note: no work done by tension, as no movement in its direction.

34. $mgh = mv^2/2$. v^2 = 2(9.8 m/s^2)(0.14 m). v = 1.66 m/s

35. $2(mv^2/2) = (4800)(22.2)^2 = 2.37 \times 10^6$ J = 2.4×10^6 J

36. $mgh - mv^2/2 = (22)(9.8)(5) - (22)(2.5)^2/2$ = 1010 J = 1.0×10^3 J

37. Initial $KE = mv^2/2$. Final Energy = $m(0.8)^2/2 + mg(2.1)$. Equate and solve.
v = 6.5 m/s.

38. (a) Initial energy = $mgL \sin\theta$
Work done by friction = $-\mu mgL \cos\theta$
Final $KE = mgL(\sin\theta - \mu\cos\theta) = mv^2/2$

$$v = [2(9.8)(80)(\sin 18 - 0.08 \cos 18^{\circ})]^{\frac{1}{2}} = 19.1 \text{ m/s}$$

(b) $mv^2/2 = \mu mgD$. $D = (19.1)^2/0.08/9.8/2$ = 233 m

39. Frictionless work = (100 N)(10 m) = 1000 J
Friction work = (100 N)(10 m) − (0.20)(60 kg)(9.80 m/s²)(10 m) = −176 J
Net work = 1000 J − 176 J = 824 J

$$824\ \text{J} = \frac{1}{2}(60\ \text{kg})v^2 - \frac{1}{2}(60\ \text{kg})(0\ \text{m/s})^2$$

v = 5.2 m/s

40. Total energy/m = $[gh + v^2/2]$ is conserved. Initially E/m = 295.62. Hence $v^2 = 2(295.62 - 9.8\ h)$.
At B, v = 24.3 m/s. At C, v = 10.1 m/s. At D, v = 18.9 m/s.

41. $$m(9.80\ \text{m/s}^2)(30\ \text{m}) - \frac{1}{5}m(9.80\ \text{m/s}^2)(67.0\ \text{m}) = \frac{1}{2}mv^2 - \frac{1}{2}m(1.20\ \text{m/s})^2$$

v = 18.1 m/s

42. $$\frac{1}{2}mv^2 = \frac{1}{2}m(300\ \text{m/s})^2 + m(9.80\ \text{m/s}^2)(280\ \text{m})$$

v = 309 m/s

43. Answer (b) first. $mgh = kx^2/2$. $h = (0.4\ m)^2(850\ \text{N/m})/2/(0.3\ \text{kg})/(9.8\ \text{m/s}^2)$ = 23.1 m.
The maximum velocity the ball has when it passes the equilibrium point.
Hence $mV^2/2 + mg(0.4\ \text{m}) = mg(23.1\ \text{m})$. V = 21.1 m/s.

44. x = maximum displacement of spring.
$kx = ma = 5\ mg$, $x = 5\ mg/k$
$mv^2/2 = kx^2/2$, $mv^2 = k(5\ mg)^2/k^2$
Thus $k = 25\ mg^2/v^2 = 25(1500)(9.8)^2/(25)^2$ = 5760 N/m = 5.8×10^3 N/m.

45. (a) mgh = (78 kg)(9.8 m/s²)(100 m) = 7.64×10^4 J.

(b) $Fd = F\pi(0.36\ m)\text{N} = 7.64 \times 10^4$ J, where N is number of times to turn pedal.
N = (100 m/sin 12°)/(5.10 m). F = 717 N.

46. 1500 W = (400 kg)(9.8 m/s²)(15.0 m)/t
t = 39.2 sec

47. 100 km/h = 27.8 m/s
15(746 W) = F(27.8 m/s)
$\underline{F = 4.0 \times 10^2 \text{ N}}$

48. British hp = 550 ft–pound/s = (550 ft–pounds)(0.305 m/ft)(4.45 N/pound)/s
= 746 N·m/s = 746 W.
Difference = 100 × (750 − 746)/746 = 0.536%.

49. 1 kWh(1000 W/kW)(3600 s/h) = 3.6×10^6W . s = $\underline{3.6 \times 10^6 \text{ J}}$. This has units of energy.

50. Power = Energy/sec = 0.5(1200 kg)[$25^2 - 19.4^2$](m/s)^2 /5 s = 2.98×10^4W = R(22.2 m/s).
$R = 1.34 \times 10^3$ N. Power = Rv = $\underline{2.98 \times 10^4 \text{ W}}$ or 39.7 hp.

51. Work = Watts . sec = 2(750 W)(3600 s) = $\underline{5.4 \times 10^6 \text{ J}}$.

52. Power = Energy/time = (0.5)(7.3 kg)(15 m/s)^2/2 s = 411 W.

53. mgh/t = (4.00 kg)(9.8 m/s^2)(2.85 m)/(60 s) = 1.86 W.

54. mgh/t = (75)(9.8)v sin 15° = (0.25 hp)(746 W/hp)
v = 0.980 m/s

55. Power is mg v sin θ + Fv = (1000 kg)(9.8 m/s^2)(16.7 m/s) sin θ + (500 N)(16.7 m/s)
= (100 hp)(746 W/hp). θ = 23.9°.

56. Friction power = (75 kg)(9.80 m/s^2)(6.0 m/s) sin (6.6°) = 507 W
Uphill power is (75 kg)(9.80 m/s^2)(6.0 m/s) sin (6.6°) + 507 W = 1014 W = $\underline{1.0 \times 10^3 \text{ W}}$

57. (a) $mv^2/2 = mgh$. v^2 = 2(9.8 m/s^2)(20 m), v = 20 m/s

(b) $mgh - Rh = mv^2/2$. R(20 m) = (0.25 kg)(9.8 m/s^2)(20 m) − (0.25 kg)(9.0 m/s)^2/2.
Solve, R = 1.9 N.

(a) $v = \underline{(2gL)^{\frac{1}{2}}}$.

(b) $mgL = mg[2h - L] + mv^2/2$. $v = [4g(L - h)]^{\frac{1}{2}} = [4g(0.25L)]^{\frac{1}{2}} = \underline{(gL)^{\frac{1}{2}}}$.

59. ΔKE = total W
$-mv^2/2 = -\mu mg \cos\theta\, s - mg \sin\theta\, s$.
$\mu = (13.8 \text{ m/s})^2/2/(11.4 \text{ m})/(\cos 20^\circ)/(9.8 \text{ m/s}^2) - \tan 20^\circ = 0.543$

60. (a) $mgh = (70 \text{ kg})(9.8 \text{ m/s}^2)(4200 \text{ m} - 2700 \text{ m}) = \underline{1.03 \times 10^6 \text{ J}}$

(b) Watts = Joules/sec = $(1.03 \times 10^6 \text{ J})/(4 \times 3600 \text{ s}) = \underline{71.4 \text{ W}}$. hp = Watts/(750 W/hp) = $\underline{0.0953 \text{ hp}}$.

(c) Power delivered = (15/100)(Power input). Power input = $\underline{476 \text{ W}}$.

61. $kx_0^2/2 = kx^2/2 + mv^2/2$

62. By conservation of energy $mgh = mv^2/2 + mg2r$. But just to fall off $mv^2/r = mg$. Hence, $h = \underline{5r/2}$.

63. (a) $mgh = (750 \text{ kg})(9.8 \text{ m/s}^2)(25 \text{ m}) = \underline{1.84 \times 10^5 \text{ J}}$.

(b) $v^2 = (2\text{ E/m}) = 2(1.84 \times 10^5 \text{ J})/(750 \text{ kg})$. $v = \underline{22.1 \text{ m/s}}$.

(c) Initial energy + W = Final Energy.
$1.84 \times 10^5 \text{ J} + (750 \text{ kg})(9.8 \text{ m/s}^2)x - 0.5(4 \times 10^4 \text{ N/m})x^2 = 0$. Solve, $x = \underline{3.22 \text{ m}}$.

64. Work = $(0.90)(60 \text{ kg})(9.80 \text{ m/s}^2)\, 2\pi\, (0.18 \text{ m}) = 598.5 \text{ J}$
This assumes the work is done continuously as the pedals spin.
The wheels cover a distance $2\pi(0.34 \text{ m})(42/19) = 4.72 \text{ m}$
Work done = $(60 \text{ kg} + 12 \text{ kg})(9.8 \text{ m/s}^2)(4.72 \text{ m}) \sin\theta = 598.5 \text{ J}$
$\theta = \underline{10.3^\circ}$.

65. Maximum acceleration occurs when spring is fully compressed. $kx - Mg = Ma = M\,5\,g$,
Energy: $kx^2/2 = Mg(x + h)$. Eliminate x, $k = \underline{49.5(Mg/h)}$. 7 12 7

66. $F = kx$. Therefore $k = 20/0.18 = 111$ N/m. We have ignored friction in this calculation. Energy stored in spring is $kx^2/2 = 1.8$ J. Energy conservation gives $1.8 - \mu mg(0.18 + e) = ke^2/2$ where 'e' is the extension when spring comes to rest. Hence $e = 0.166$ m.

67. (a) $mv^2/2 = mgh$. $v = \underline{48.5 \text{ m/s}}$

(b) Power available is $(88/100)(800)(48.5)^2/2 = 8.28 \times 10^5$ W.
Velocity of waste water is $(0.2)(48.5) = 9.70$ m/s.
Power wasted is $(800)(9.7)^2/2 = 0.38 \times 10^5$ W.
Hence power transferred is 7.90×10^5 W.

68. $mg \text{ v} \sin\theta = F\text{v} = b\text{v}^2$.
$(80 \text{ kg})(9.8 \text{ m/s}^2)(\sin 3.4°) = b(2.5 \text{ m/s})$. $b = 18.6 \text{ N}\cdot\text{s/m}$.
Power developed by cyclist is P.
$P + mg \text{ v} \sin\theta = b\text{v}^2$.
$P = (18.5 \text{ N . s/m})(8.33 \text{ m/s})^2 - (80 \text{ kg})(9.8 \text{ m/s}^2)(8.33)(\sin 3.4°) = \underline{903 \text{ W}}$.
Now climbing hill: $903 \text{ W} = (18.6 \text{ N . s/m})\text{v}^2 + (80 \text{ kg})(9.8 \text{ m/s}^2)\text{v} \sin(3.4°)$.
Solving, $\text{v} = \underline{5.83 \text{ m/s}}$.